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ABSTRACT

This paper reports on a pilot study that is designed to become an element of a larger research endeavor. The larger study will explore relationships between how teachers teach in the classroom, those teachers' perceptions of their own pedagogical practice, and the beliefs of those teachers about the roles of the student and the teacher in the learning environment. The purpose of this pilot study was to develop a rubric to assess teachers' beliefs about constructivist teaching and learning. Study participants included 20 teachers with teaching assignments ranging from the grades 6-10. An open ended question "My perception of the relationship between students and teachers in the learning environment..." was used to invite responses in the teachers' own words. The scoring rubric, the Science Teacher's Belief about the Learning Environment, used 13 characteristics to assess teachers' beliefs. Although individual responses included a variety of forms, the utility of the rubric design was evident in the relatively equal ease of use in assessing the varied responses. It can be inferred that there is good evidence of a theoretical construct in the case of the "Science Teacher's Beliefs about the Learning Environment" scoring rubric. (Contains 46 references.) (ND)

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Beliefs of Constructivist Teachers Using A Novice Through Expert Rubric

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Beliefs of Constructivist Teachers Using A Novice Through Expert Rubric

Teachers are considered important agents of change in today's science education reform efforts. Roychoudhury and Butler-Kahle (1995) refer to the teacher as a central agent of reform in school improvement. Hurd (1992) and Yager (1994) suggest that to move to a "reformed practice, we need to pay attention to 'how' teaching should be done in reformed classrooms and what the experiences of qualified science teachers mean for transforming science education" (as cited in Roychoudhury, Tippins, and Nichols, 1995 #76, p. 2). To better map growth among individuals participating in improvement programs or planned projects, benchmarks as well as progress, must be defined and documented.

A practical question which reformers should ask is: "Are the teachers transitioning to more effective strategies *and will it last*?" Linking changed practices and evolving beliefs is one way to address this question. Teacher growth is often documented, but little has been done linking practice to beliefs among the reform efforts, or for that matter among general studies of teachers' beliefs (Hashweh, 1996; Hewson, Kerby & Cook, 1995b; Kagan, 1990; Kagan, 1992b). This study is designed to explore a method of capturing the beliefs of teachers regarding the relationship between the student and the teacher in the learning environment. The eventual extension will be the study of the relationship between beliefs and practice among the subpopulation studied.

Background and Context

For reformers to link practice to beliefs, alternative and more utilitarian approaches, which capture teachers' thinking the teaching-learning experience, within defined categories, must be developed. This paper reports on a pilot study of one such alternative instrument to document

teachers beliefs. To assess the beliefs of teachers related to constructivist teaching, an open-ended question and supporting rubric to quantify teachers' responses was created.

Background

The practical considerations which guide this effort are linked directly to the Iowa Scope, Sequence and Coordination (SS&C) Project. This National Science Foundation funded teacher enhancement project in Iowa is in its second phase and seventh year (having begun in 1990). The Iowa SS&C Project is a teacher enhancement project emphasizing constructivist learning theory and the Science-Technology-Society (STS) paradigm, development of context-based assessment practices and tools, and development of materials which emerge out of the context of the teachers' experiences in student-centered instruction.

Documentation of SS&C teachers' classroom practice, in particular that demonstrating constructivist teaching habits, has been a priority. An early limitation, however, was the identification of tools and methodologies which could consistently and more objectively capture constructivist teaching habits. It was determined that classroom observations would be an effective way to document constructivist teaching habits (Burry-Stock, 1995a; Evertson & Burry, 1988). Evertson and Burry[-Stock] (1988) advocate classroom observation, noting that it is one of the single most important factors in systems that assess competence of classroom teachers. Eventually an instrument was identified, the Science Classroom Observation Rubric , a key element of the Expert Science Teaching Education Evaluation Model (ESTEEM), (Burry-Stock, 1995b) to be used to qualify constructivist teaching characteristics among SS&C teachers.

As data were gathered and reported it became apparent that teachers were transitioning to more constructivist teaching practices (Liu, Varrella & Yager, 1995; Varrella & Blanck, 1995, July). However, the teachers' thinking and beliefs about the student-teacher relationship in the learning environment up to this point, has not been well-documented. Journaling was successfully used as a measure of teacher growth, reflection, and change by the Iowa Chautauqua project (Yager, Liu & Blunck, 1993), but is time intensive for the researchers and becomes tedious for the

participants (especially over a lengthy project period such as this one). Clearly a more utilitarian measure is needed.

Constructivism

Constructivism is a theory of learning which readily includes the issues of teaching complexity, teacher learning, and to a lesser degree leads into curriculum and theory of science (Hewson, Kerby & Cook, 1995a; McComish, 1995; Yager, 1992). A constructivist view of teaching and learning assumes that learners construct their own knowledge. With time the personal constructions of learners become stable patterns of belief. Though these patterns and constructions are often naive and ill-structured, they are tenaciously maintained in the minds of the learner. Individuals tend to measure the degree of congruence of other beliefs and conceptions against those beliefs and understandings which they have previously constructed (Millar & Driver, 1986; Rokeach, 1970).

To encourage a transition to a more accurate and rich understanding of the natural world a learning environment which is experientially-based and student-centered is called for (Yager, 1992). In such an environment the students must ask and pursue explanations to questions and resolve emerging cognitive conflicts between what is personally known and what is considered the best current thinking on the subject of study. The net result in such a classroom is personal growth and a richer more scientifically accurate understanding on the part of the learner (Pope & Gilbert, 1983; Yager, 1994).

This not to imply that learning is solely an individual process. Learning is influenced by a variety of social factors and experiences (Hewson et al., 1995a; Jakubowski & Tobin, 1991; Phillips, 1995). Though the construction of knowledge and understanding occurs in the mind of the individual, the social and cultural milieu effect the personal negotiation of meaning and value of the knowledge for the individual through processes such as, " . . . describing, questioning, clarifying, justifying, elaborating, evaluating, synthesizing, analyzing, and building consensus." (Jakubowski & Tobin, 1991, p. 203).

Teacher Beliefs

When the teacher assumes responsibility for the learning experiences of their students each morning, what affects the instructional decisions that they will make? While a host of intrinsic and extrinsic factors come into play, many studies point to individual beliefs as strong indicators of the instructional choices and teaching pattern of individuals (Bandura, 1977; Lumpe & Haney, 1996; Prawat, 1992). Pajares (1992) believes "that the investigation of teachers beliefs is a necessary and valuable avenue of educational inquiry" (p. 326). As support for this statement, among the many points in his synthesis of findings on beliefs, Pajares (1992) points out that, "Individuals' beliefs strongly affect their behavior" (p. 326).

This common sense notion is also supported by a growing body of literature on cognition (Clark & Peterson, 1986; Kagan, 1990; Kagan, 1992a; Pajares, 1992) and beliefs (Pajares, 1992) However, very few of these studies have explored the effects or relationships of these beliefs to teaching (Hashweh, 1996). Hewson, Kerby, and Cook (1995b) believe it is critical to understand what science teachers do and why they do it, "i.e., to understand the thinking that informs their actions" (p. 518). Beck and Lumpe (1996) make a natural extension of this work, suggesting that, "As such, teacher beliefs must be addressed in order for reform efforts to work" (p. 3).

Beliefs and Reform

In their study on factors that affect how teachers teach, Talbert, McLaughlin, and Rowan (1993) explain that reformers know little about the interdependence of the teaching environment, the nature of classroom practice, and student learning. They further suggest that teachers are insulated behind their classroom walls, which buffers them from external influences. This is not to imply that teachers are isolated from their peers and administrators, but rather that the sources of influence are less apparent that in other types of organizations (Talbert et al., 1993). The diverse environmental or conditional effects intersecting with the work of teachers has been labeled the "*context effect* " (Talbert et al., 1993). These context effects which influence teaching practice include values, beliefs, norms, policies, structures, resources, and processes initially impacting teaching practice and, in turn students' educational outcomes (Talbert et al., 1993).

Each of these factors are important to school change agents and to schools interested in broad reform efforts which embrace the variety of stakeholders in education (Senge, 1990). Student growth, change in programs, teacher testimonies, and complementary curriculum are all provided as evidence of reform; however, there is a scarcity of reform related research linking teachers and their beliefs to reform efforts. While studies linking beliefs to larger staff development agendas are beginning to surface (Beck & Lumpe, 1996; Lumpe & Haney, 1996), there is need for more (Hewson et al., 1995b; Kagan, 1990).

Instrument Development

The study described here is designed to become an element of a larger research endeavor. The larger study will explore relationships between how teachers teach in the classroom, those teachers' perceptions of their own pedagogical practice, and the beliefs of those teachers about the roles of the student and the teacher in the learning environment. This pilot is designed to test the teacher beliefs component.

Theoretical Basis For The Rubric

Munby (1986) believes it is important to capture the words of the teachers in their own language, rather than in the language of the researcher. Hence an open ended question, "My perception of the relationship between students and teachers in the learning environment is:" was used to invite a response in the participating teachers' own words. This question actually evolved from a related question the researcher used in an off-campus course on constructivist teaching. In that instance the relationships between the teacher and the students were tied together using a mind mapping or webbing approach. The richness and diversity of the teachers' responses in that instance lead to this pilot.

A scoring rubric has been drafted to quantify the teacher responses to the above question. The rubric is built around the process of analysis used by Hewson and Hewson (1989) to reveal teacher's orientation toward science. It was first tested with 30 students enrolled in a preservice program in secondary science teaching (Hewson & Hewson, 1989). The technique of analysis for

determining teachers conceptions of teaching science was originally developed by Osborne and Gilbert (1980) to explore the associations between certain concepts and particular labels (Kagan, 1990). Kagan (1990) summarized the categories that were used to evaluate the teachers conceptions from the Hewson and Hewson (1989) study:

I. Nature of Science: Statement refers to the content to be taught, objective of teaching; natural phenomena that are investigated; . . .

II. Learning: Any statement that refers to learning, including how people learn, . . .

III. Learner Characteristics: Any statement that refers to characteristics likely to influence how and what a person learns, including a person's knowledge, . . .

IV. Rationale for Instruction: State that refers to the reasons that a person [teacher] may give for using a particular instructional method . . .

V. Preferred Instructional Techniques: Any statement that refers to the strategies, methods, or practices that the person would use in teaching. . . .

VI. Conceptions of Teaching Science: Any statement that refers to the person's [teacher's] conception of the components of teaching science and their interrelationships. . . ." (p. 440)

In the more recent study by Hewson, Kerby, and Cook (1995b) this same analysis was used to determine experienced high school science teachers' conceptions of teaching science (CTS). The study was designed to allow participants to respond, without introduction of new terms by the interviewer, to a series of 10 learning events both in and outside of a classroom setting. A qualitative analysis was done using the transcripts of the interviews again referring to the six categories described above. A theme analysis grid was employed grouping the six listed categories into four: Nature of science, learning/learner, rationale and instruction, and teaching (Hewson et al., 1995b). These four categories were used to define the four categories included in the development of the "Science Teacher Beliefs About The Learning Environment" rubric.

This theoretical foundation is further strengthened by alignment with Everton's "Model for Investigating Science Teaching and Learning" (Everston, 1990, March, p. 3). In this model

Evertson (1990, March) placed the, "Instructional event: "The moment of bringing teachers, students, and materials together with the intention of bringing about learning" (p. 3) at the point of overlap between the subsystems of the teacher, student (group and individual), and materials. This event was set in the milieu of the supersystems of the classroom and the community (Everston, 1990, March).

If one accepts that the teacher's interpretation of the nature and meaning of science is important and can have direct impact on the learning event (Brickhouse, 1990; Duschl & Wright, 1989; Hewson & Hewson, 1989; Hewson et al., 1995b; Munby, 1986), then the nature of science becomes an element within the teacher component of Evertson's model (1990, March). The Model For Investigating Science Teaching and Learning, has been reproduced in Figure 1 below.

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Insert Figure 1 here

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Using these two theoretical models for organizers, a series of characteristics have been defined using literature on constructivism and related studies on beliefs (Brooks & Brooks, 1993; Everston, 1990, March; Hashweh, 1996; Jakubowski & Tobin, 1991; Minstrell, 1992; Osborne & Wittrock, 1985; Pajares, 1992; Phillips, 1995; Posner, Strike, Hewson & Gertzog, 1982; Yager, 1992). The final characteristics were adjusted and modified by the comments of the teachers who responded to the original open-ended question (Miles & Huberman, 1994).

Participants

The subpopulation used for this pilot of the rubric, the Science Teacher Beliefs About The Learning Environment included 20 teachers. All but two are participants in the Iowa SS&C project and have teaching assignments in grades ranging from sixth to tenth.

Rubric Structure

The Science Teacher Beliefs About The Learning Environment rubric (see Table 1 for an example) contains four general categories including, Category I — rationale and teaching (preferred instructional techniques), Category II — conception of teaching science, Category III — the learner and learning environment, and Category IV — the nature of science. These four categories were used to generate 13 items, each of which is captured by a specific statement. Under each of these categories are a series of characteristics gathered from the literature on constructivism (Brooks & Brooks, 1993; Burry-Stock & Oxford, 1994; Hewson et al., 1995a; Minstrell, 1992; Roychoudhury et al., 1995; Yager, 1992), the literature on teacher beliefs and conceptions of teaching science (Calderhead, 1987; Hashweh, 1996; Kagan, 1990; Kagan & Tippins, 1992; Pajares, 1992), and empirical evidence gathered from teachers.

The rating scale for each of these 13 characteristics has a range of one to five with five being the highest. This response mode is a behaviorally anchored rating scale. It is designed to assess the relative importance of each of the 13 categories to the individual teacher as communicated through their response to the open-ended question (described above). The range of statements is from a "1 - Not identified as a feature . . ." to a "5 - Discussed with clarity and linked to other related elements." Table 1 contains three sample characteristic statements from two categories and a listing of the five levels of response that are common to all 13 of the characteristics:

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Insert Table 1 about here

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Results of the Pilot Study

The data for this pilot study are presented in two parts. Table 2 shows the item to total correlation analysis. The reliability's were calculated using a Cronbach alpha reliability coefficient for items one through twelve (N = 20). Item 13 (statements regarding the nature of science) is not included in the analysis because there was essentially no variation in the scores on this characteristic in the pilot (i.e., 19 of the 20 responses were scored as a, 1 — not identified as a feature of the student and teacher relationship in the learning environment). The means are not high; however, there is variability within the pilot study group.

All item-to-total reliability's were rounded to the nearest tenth for convenience at this stage of the development and testing of the rubric. All item-to-total calculations are very respectable ($\geq$ .4) which indicate that the items are measuring the theoretical construction. In this instance the theoretical construct is represented by the first twelve items found in the Science Teacher Beliefs About The Learning Environment Rubric.

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Insert Table 2 about here

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Table 3 illustrates the assessment of the 20 teacher responses for this pilot. The data were analyzed using a principle component solution with an orthogonal rotation revealing five significant factors. The highest loading was taken for each item listed. The sum of the squares of the factor load accounted for 80.8% of the variability (SS = 9.65) for the first 12 characteristics in the Science Teacher Beliefs About The Learning Environment Rubric. All of the 12 characteristics have factors loadings from .91 to .48.

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Insert Table 3 about here

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Discussion

In her review of the "ambiguities and paradoxes in the literature on teacher cognition Kagan (1990, p. 451) pointed to the variety of epistemological traditions which define the techniques used in research on teacher beliefs and the actual terminology itself. In this study teacher's beliefs refer to a teacher's personal conception about the relationship between the student and the teacher in the learning environment. In this study the developmental technique used to create the Science Teacher Beliefs About the Learning Environment was that of using theory heuristically (Calderhead, 1987; Kagan, 1990). The beliefs rubric is based on a constructivist view of teaching and learning (Brooks & Brooks, 1993; Burry-Stock & Oxford, 1994; Hewson et al., 1995a; Minstrell, 1992; Roychoudhury et al., 1995; Yager, 1992) and on research in teacher conceptions and learning environments (Everston, 1990, March; Hewson & Hewson, 1989; Hewson et al., 1995b). Empirical evidence in the form of teacher responses to the open-ended question were used to interact with and modify the initial design of the rubric prior to analysis for the purposes of this pilot study.

Since the teachers responded to an opened question, the structure of the individual response varied widely. Among the twenty teachers reported on here, replies came in many forms including narratives, lists, concept maps or webs, matrices, or combinations of more than one of the above (e.g. a concept map accompanied by an introductory paragraph). The utility of the rubric design was shown through the relatively equal ease of use for assessing responses in the variety of modes describes above.

The troublesome lack of variability among teachers' comments on the nature of science caused item 13 to not be included in this preliminary study. This aspect will need further consideration in the future. One possibility may be to interview a select subset of participating teachers to explore more directly their views about the nature and meaning of science. It also could be that the responses are further evidence of the atheoretical nature of science teacher preparation programs which may explain teachers' lack of knowledge about the nature of science (Duschl & Wright, 1989)

Limitations

There are several limitations to the pilot study reported on in this paper. The size of the study population is small (N = 20). Building the theoretical construct was confounded by the nebulousness of the literature and research on beliefs (Clark & Peterson, 1986; Kagan, 1990; Kagan, 1992a; Pajares, 1992). Another limitation is the amount of empirical data which can be collected through teachers' responses to a single open-ended question and the related concerns about the nature of self-reported data. One must wonder, unless clearly stated by the writer, if the teacher's views were an ideal or a reality which guides the individual's practice each day. Keeping in mind that this is a pilot study, the degree of applicability to other teachers remains unknown due to the nonrandom selection process.

Implications

The factor analysis indicates promise that the Science Teacher Beliefs About the Learning Environment rubric can measure teacher belief statements in response to the open ended question used in this study. However, the ordering of the 12 items included under the five factors indicates that the clustering of characteristics under the categories needs further consideration. For example, factor 3 included two characteristics, "G - Teacher-Student Relationship," and "J. - Student Autonomy—the importance of [valuing] students' opinions" which accounts for 17.2% of the variability. These two characteristics are currently listed under two different categories as they were derived from the theoretical model (Hewson & Hewson, 1989; Hewson et al., 1995b), "Category II. Conceptions of Teaching Science," and Category II. The Learner and the Learning Environment."

The checks and balances of the triangulation will augment validity and reliability of the constructs and the premises (Duschl & Wright, 1989; Mathison, 1988) of this rubric. Triangulation will also address questions driving the previously mentioned broader study on the relationships between what teachers think and do in a constructivist teaching and learning environment.

As with most research, questions lead to more questions. The richness of the qualitative literature on beliefs begs the need for interviews of at least some participating teachers. Teachers' responses related to perceptions of their classroom routine should be further explored as well (e.g., was it an ideal or a reality that was addressed in *your* written response?). Also this might be the most effective way to explore the noteworthy lack of reference to the nature of science among the pilot population. Interviews should be conducted with selected teachers from at least two levels within the range of assessed scores (i.e., low - high).

"Not only do we want to verify through research what needs to happen, but we also need to validate that it has happened and that it works or does not work" (Burry-Stock, 1995a, p. 64) Application to school reform is the logical extension, exploring not only what teachers do, but how they think.

Conclusion

The purpose of this study was to address the development of a rubric which can be used to assess teachers beliefs about constructivist teaching in the learning environment. The analysis of the empirical data, using the pilot rubric and the Science Teacher's Beliefs About the Learning Environment demonstrates content validity with high item-to-total correlations. Construct validity was demonstrated through 80.8% of the variability being accounted for by five factors in a principle component analysis with an orthogonal solution. Therefore it can be inferred that there is good evidence of a theoretical construct in the case of the Science Teacher's Beliefs About the Learning Environment.

Additional studies will be done to further validate the instrument. The issue of reliability and interrater agreement will also need to be addressed as well as exploring teacher thinking related to the nature of science. Secondary questions may also be explored through further study: What factors do teachers most commonly refer to when explaining their beliefs about a constructivist learning environment; and how are those beliefs evidenced through classroom practices?

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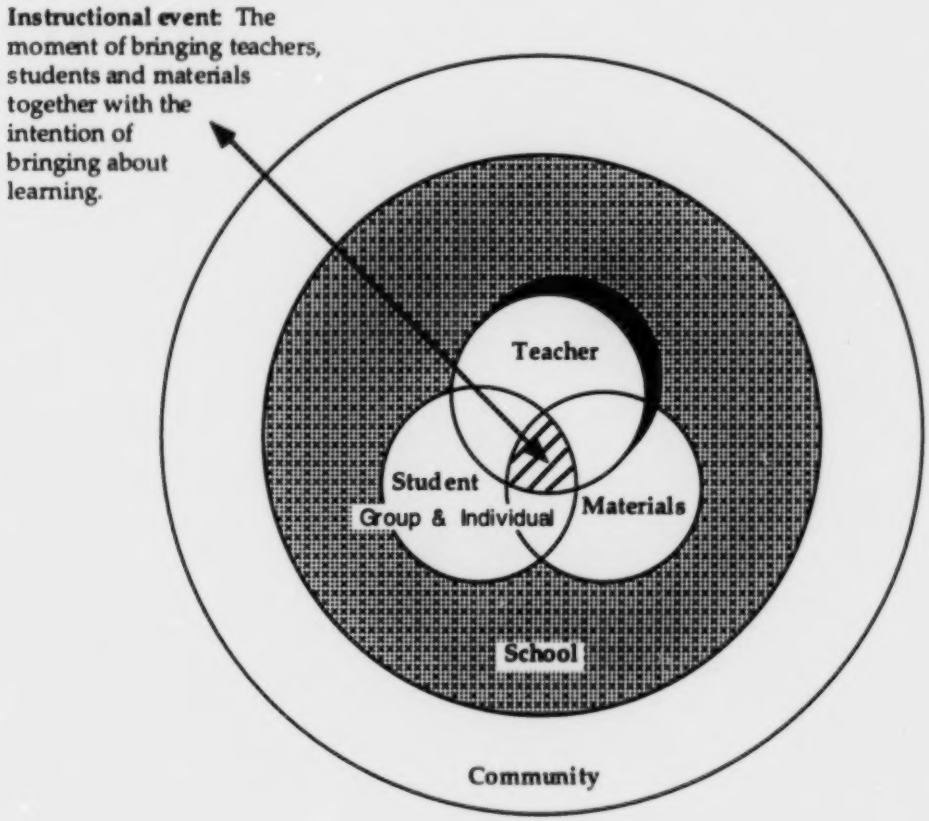

Figure 1. Evertson's (1990, March) "Model for investigating teaching and learning" (p. 3). Certain elements have been enhanced for clarity and to demonstrate the focus on the teacher in this study.

Table 1

Sample Characteristics and Response Mode Scale* for the Science Teacher Beliefs About the Learning Environment Rubric.

G. Teacher-Student Relationship

The teacher identifies the value of working *with* the students emphasizing such habits as mutual respect and cooperative-problem solving. (p. 2)

5 Discussed with clarity and linked to other related elements.

4 Discussed or linked to other related elements.

3 Identified as a term and/or in a list.

2 Alluded to or loosely included, but not clearly stated, even just as a term.

1 Not identified as a feature of the student and teacher relationship in the learning environment.

H. Construction of Student Conceptual Understanding (seek, identify and resolve inconsistencies)

The teacher's goal is to help the students develop a conceptual understanding. Examples might include addressing students' mis- and pre-conceptions and the engagement of students in activities which may generate contradiction and dialog and the eventual restructuring of existing knowledge. (p. 2)

J. Student Autonomy — the importance [valuing] of students' opinions

The teacher values and seeks to understand the students' points of view. Within the context of the subject(s) of the class the students' interests and question heavily influence and shape the instructional plans. (p. 4)

Note. The response mode scale shown under characteristic G above is used for all characteristics, but is shown only once here for convenience.

Table 2

Table of Means, Standard Deviations, and Item-To-Total Calculations

Variable	M	SD	Item to Total (correlation coefficient)
Item 1	3.10	1.52	.79
Item 2	1.40	.60	.39
Item 3	1.50	.76	.75
Item 4	1.35	.49	.49
Item 5	1.70	1.08	.69
Item 6	1.45	.94	.62
Item 7	3.10	1.80	.62
Item 8	1.50	.83	.76
Item 9	1.95	1.23	.69
Item 10	2.20	1.40	.80
Item 11	1.40	.50	.66
Item 12	1.35	.59	.44

Note. Item 13 not included (M = 1.05)

Table 3

Principle Component Analysis With An Orthogonal Solution For the Science Teacher Belief About The Learning Environment Rubric (N = 20)

Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Item 11	.88				
Item 9	.68				
Item 1	.63				
Item 12	.50				
Item 8	.48				
Item 3		.84			
Item 5		.75			
Item 6		.72			
Item 7			.89		
Item 10			.75		
Item 2				.89	
Item 4					.91
Sum of the square of the loading factor	2.389810	2.338264	2.056717	1.480886	1.3890791
% Variance	19.9	19.5	17.1	12.3	11.6

Note. The sum of the squares of the factor loadings = 9.654748 which accounts for 80.8% of the variability. Item 13 is not included